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Gun Mount	Stabilization (Artillery)	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This Report

Describes a method of evaluating vehicular gun stabilization system performance over standardized test courses. Includes tests for frequency response, hull displacement, and stabilizer performance in firing and nonfiring modes with both stationary and moving targets. Appendices provide test summary charts.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-102
*Test Operations Procedure 3-2-602 — 28 July 1983
AD No.

GUN STABILIZATION SYSTEMS (VEHICULAR)

1. SCOPE. This TOP describes performance tests of vehicular weapon stabilization systems. The effectiveness of the stabilized gun control systems is evaluated in terms of ability to maintain the line of sight on specific targets while the tank or gun carriage is subjected to random input motions from traveling over specified test courses. Included are tests to determine elevation and azimuth servo system response, hull displacement in relation to test course characteristics, and time-on-target (nonfiring) and firing-on-the-move characteristics.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

2.1.1 Stabilization Test Courses. The courses listed below are located at Aberdeen Proving Ground (APG) and, except for d (gently rolling terrain), are described in TOP 1-1-011[1**] and APG drawing 12521-15. Equivalent courses may be used.

a. Gravel Course. A straight, level, gravel road 2,500 m in a direct line closing with the target. Operation on this course provides data for evaluating the stabilization system in an environment of minimum disturbance from the course.

*This TOP supersedes TOP 3-2-602 dated 19 September 1976.

**Footnote numbers correspond to reference numbers in Appendix C.

b. Bump Course. A straight, level, blacktop road in direct line with a stationary or crossing target with a series of trapezoidal wooden or metal blocks located at random positions. The bumps are 11.4 cm and 15.2 cm (4-1/2 and 6 in) high with a base length of 2 m (6 ft). The range from the course starting point to the target is 3000 meters. Bumps, which are portable, may be arranged for a shorter range to target. Operation on the bump course provides an abrupt, vertical and horizontal randomly spaced disturbance.

c. Zig-Zag Course. A level road with a series of turns and straight line segments that alternately cross the line of approach to a stationary or crossing target at a 45° angle every 76 m. The radii of the turns vary from 33.6 m to 42.7 m (110 to 140 ft) to produce an average lateral displacement of about 35 meters. Range from the course starting point is 3000 m. Operation on the zig-zag course provides data for evaluating the stabilization system in a course environment of large azimuth displacements.

d. Gently Rolling Terrain (GRT). A straight, natural (earthen), rolling terrain course 2,000 m in a direct line closing with the target. Operation on this course provides a gentle cross-country environment with random undulations.

2.1.2 Targets. Made of expendable material such as cloth or plywood, containing a marked 2.3-m-square area with a 0.25-m bull's eye for main gun tests (4.6 by 2.3 m for moving targets) and marked areas 0.9 by 1.2, 2.3, and 5.5 by 5.5 m for machine gun tests.

2.1.3 Moving Target Facility. A remotely controlled moving target fixture as described in TOP 1-1-011. As an alternative, the "laser dot" Live Fire Evasive Target System (LFETS) facility can be used.

2.2 Instrumentation.

ITEM	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENT*
Video Tracking System (a below) or Gun-mounted film camera (b below)	Angular distance between line of fire, line of sight, and target to ±0.1 mrad
Rate sensor	Turret and hull rates (pitch, roll, and yaw) to ±0.5 mrad/sec
Frequency response analyzer (c below)	Input/output signal ratio to ±0.15 db, phase angle to ±1°
Automated Video Target Scoring System (d below)	Projectile impact: azimuth and elevation ±0.1 mrad
Automotive/fire control data-acquisition system (telemetry test site terminal and fire control data-acquisition unit) (e below)	

*Values may be assumed to represent ±2 standard deviations; thus, the stated tolerances should not be exceeded in more than 1 measurement of 20.

ITEM (Cont'd)	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENT (Cont'd)
Meteorological equipment:	
Wind speed	0 to 44.7 m/s, ± 0.8 m/s (0-100 mph, $\pm 3/4$ mph)
Wind direction	360° $\pm 3°$
Ambient temperature	-35° to +50° C $\pm 0.2°$
Relative humidity	5% to 100% RH $\pm 1\%$

a. Video Tracking System. Includes the following components:

(1) Gun-mounted television (TV) camera
(2) Cooperative target source (light)
(3) Video processor (TV tracker)
(4) TV monitor
(5) Microwave link

The video output signal of the camera is transmitted via a microwave link to the TV tracker which processes the video signal to give the azimuth and elevation position of the target in the TV camera's field of view. Target position is recorded in a digital format by the telemetry test site terminal. Additional information on video tracking systems is contained in report APG-MT-5069.[2]

b. Gun-Mounted Film Camera (alternative to Video Tracking System). A rugged 16-mm camera with a framing rate of 16 to 128 frames per second. Both a wide angle (90°) lens and a lens of high magnification (6-inch focal length) are required.

c. Frequency Response Analyzer. A low-frequency function generator capable of producing sine wave random signals over the frequency range of 0.1 to 25 Hz and comparing system input or driving signals with system sensor output or response signals.

d. Automated Video Target Scoring System (AVTSS). The AVTSS serves as an alternative to manually scoring hits on target. A video camera is focused on the target with the camera axis as closely orthogonal as possible to the plane of the target. The camera is located as close as possible to the target to provide good viewing with minimal geometric distortion. Because the camera is the transducer for this system, it must be a high-quality linear camera. The video signal from the camera is then processed by a video digitizer. The output of the digitizer is the X and Y (azimuth and elevation) positions of an operator-controlled cursor visible on the video monitor. This output is connected to a computer which scales and logs the data to yield scoring coordinates in engineering units. Data presentation is by means of immediate hard copy printout and a plot of impact positions. Data are also stored in computer memory for later calculations or transmission for further automatic processing.

e. Automotive/Fire Control Data-Acquisition System. This system consists of a telemetry test site terminal and a vehicle-mounted fire control data-acquisition unit. The system uses PCM telemetry techniques and employs a data merger to allow ground-originated signals to be inserted into the data stream. Additional information on this system is contained in report APG-MT-5292.[3]

3. REQUIRED TEST CONDITIONS.

3.1 Inspection and Servicing.

a. Inspect the test vehicle, including its suspension system, in accordance with TOP 2-2-505[4].

b. Perform all required maintenance and service operations for the vehicle and subsystems, including a complete lubrication, in accordance with the technical manuals, lubrication orders, or other guidance documents.

c. Check voltage levels and current outputs of electrical system (TOP 2-2-601[5]) for conformance with vehicle specifications.

d. If applicable, measure the torque friction at the turret and gun coupling locations, and record the torque readings. If necessary, disassemble, clean, and relubricate to reduce torque loads to recommended friction values.

e. If applicable, ensure that the main gun balance has been checked (TOP 3-2-603[6]) for compliance with vehicle specification. Provide weight compensation for any installed instrumentation (para 3.4) to maintain proper balance.

3.2 Stowage.

a. Stow the test vehicle with the required complement of ammunition (actual or simulated) and all item of on-equipment-materiel (OEM) to provide the moment of inertia and center of gravity of a combat-loaded vehicle.

b. Attach all equipment to the gun that is normally attached during combat, e.g., searchlight, telescope, coaxial machine gun, machinegun ammunition belt, ballistic shield.

c. Load a dummy round of ammunition, simulating the primary round carried by the vehicle, in the gun during all nonfiring stabilization system tests.

3.3 Functional Tests. Test the gun control system for proper functioning in accordance with TOP 3-2-603. With the vehicle stationary and the gun in the unstabilized mode, test the system for laying (on stationary targets) and tracking (on moving targets). Repeat these tests with the system in the stabilized mode. Record any detrimental effects of the stabilizer system on gun laying and tracking.

3.4 Instrumentation.

a. Instrument the weapon with a gun TV camera to record angular deviations from the line of sight (LOS). For systems in which the gun is mechanically linked to the sight, mount the instrumentation on the gun (tube, mantlet, or sight) in a location to minimize imbalance and parallax, and boresight the instrument parallel to the gun tube axis. For systems in which the gun is slaved to a stabilized sight, instrument both the gun and gun sight, or instrument the gun sight and monitor the synchro-positioning signals to the gun for angular deviation (provided the signal outputs are calibrated for angular displacement).

b. Mount the light source on the target at a measured distance from the center of the target. The light source is used as the aim point for the video processing system. Note that system sensitivity will change whenever the focal length of the lens used with the camera is changed.

c. Use an established target consisting of an array of lights to generate known target angle deflection data from which normalization factors can be determined. This allows video processor outputs to be converted to engineering units (mils, milliradians, degrees, etc.).

d. Connect on-board vehicle data source (e.g., rate gyro, trigger pull, synchro, etc.) to the data-acquisition module. Connect other data sources (e.g., time code generator, video processor, etc.) to data merger.

e. Fire control systems in which the gun is slaved to a stabilized sight may incorporate a firing-inhibit circuit that restricts firing to intervals at which the gun and sight are within a pre-determined alignment tolerance range. For these systems, make provision to monitor the synchro error signals that inhibit the firing pulse.

3.5 Test Controls.

3.5.1 Sights. Evaluate the effect of vibration on the sights during stabilization system testing. Vibration may cause vision through the sights to be blurred under certain operating conditions. Trace vibration problems to their sources, e.g., resonant frequencies of particular components. Evaluate coupled night vision devices. Record changes in boresight during testing.

3.5.2 Controller. Observe the effects of controller design on the performance of the stabilization system. During all phases of these tests, record degradation of controller performance. Also observe human factors aspects, e.g., location and operation of switches, control lights, etc., relative to the control handles.

3.5.3 Maintenance. Perform periodic lubrication and maintenance services during all testing in accordance with the applicable lubrication order (LO) and technical manuals.

3.5.4 Safety. Safety precautions are important during firing and nonfiring tests. Ensure that adequate protective clothing is worn, e.g., helmets, safety shoes, eye and ear protection. Inspect the system for safety hazards before testing, and continually monitor the system for hazards during testing. Record all potential and actual hazards. Some typical hazardous conditions are:

a. Failure of vehicle safety provisions to prevent injuries to the crew during operation, loading, or firing

b. Excessive smoke, toxic gases, and dust collections in the vehicle after firing

c. Failure of head supports to keep crew members' heads safely positioned at the sights during operation

d. Interference of military clothing with gunnery crew performance

3.5.5 Firing Tests.

a. Record surface meteorological data (TOP 3-1-003[7]) for each round fired.

b. Restrict firings to times when crosswinds are below 24 km/hr (15 mph), unless otherwise specified.

3.5.6 Gunners. Use experienced gunners with no uncorrected vision defects who have received qualifying training on the test system.

3.5.7 Ammunition Selection. Ammunition selected for test should be from a lot accepted without waiver which demonstrates good precision characteristics. This lot should be used throughout the entire test.

4. TEST PROCEDURES.

4.1 Frequency Response. Stabilization servo system response characteristics are not normally established in vehicle specification documents. It is obvious, however, that a good servo system is one whose output signal (response) closely matches the input signal (environment) in magnitude and duration with minimal time lag. Determination of response characteristics is necessary, therefore, to assist in providing a complete assessment of stabilization system performance.

4.1.1 Method.

a. Develop curves defining turret rate versus handle deflection, voltage to the turret system, and rate sensor output by deflecting the gun control handles a known amount and recording:

(1) Rate (angular) - from instrumentation rate sensor
(2) Handle voltage - from system test point
(3) Handle deflection - from instrumentation synchro or protractor attached to handle

b. From the above curves, determine the peak rate and associated voltages for conducting the frequency response test by selecting a point that is both on the initial linear portion of the rate curve and within the boundaries of a reasonable tracking rate.

c. Connect a frequency response analyzer to feed input driving signals to the system under test, and monitor system output. The input driving signals are fed electrically to the system at a contractor-furnished test point between the gun control handles and shaping rate sensor or instrumentation rate sensor. Place differential amplifiers in the input and output lines between the analyzer and test item to provide minimum disturbance to the test item from instrumentation attachments.

d. With the system nulled and the control handles at the zero position, feed simulated control handle commands into the system from the analyzer. These simulated commands consist of: a) a sine wave (or ramp form) at discrete frequencies from 0.1 to 25 Hz; b) random wave form. The analyzer compares the system output signal to the input or driving signal and by Fourier analysis, establishes a ratio in decibels and the phase shift in degrees. These data are

presented by a digital display on the analyzer and are recorded by the operator or alternatively by the analyzer on magnetic tape and printer/plotter.

4.1.2 Data Reduction and Presentation. Construct Bode plots using the recorded input and output signal ratios and phase shifts for the elevation and azimuth servo loops. A Bode plot is a graph of the frequency versus decibels and phase angle, showing response and phase lag of the system (see examples in Appendix A). Decibels are equivalent to:

$$20 \log \frac{E_o}{E_i}$$

in which: E_o = system output
E_i = system input

Ideally, the response would be flat from zero to some higher frequency, e.g.:

$$20 \log \frac{E_o}{E_i} = 0$$

while maintaining a zero phase lag. This type of response should be evident when viewing plots of the gunner's control handle. The hull-gyro response characteristics should be different. The hull-gyro response should peak at an approximate value in frequency where the gunner's control response begins to decline; the two inputs to the stabilization system will thus complement each other (App. A).

4.2 Performance on Test Courses. Stabilization systems are intended to aid the turret gunner in laying his/her weapon while the tank is moving. The final laying accuracy depends on the gunner's skill and training, as well as the system itself. To evaluate system performance on the stabilizer courses, both firing and nonfiring tests are conducted, the latter with and without gunner compensation (realigning weapon on target). Analysis of noncompensated test results is a quantification of stabilizer performance omitting the human biases; it also indicates the effectiveness of one stabilization system compared to the effectiveness of another.

When stabilizer performance criteria have not been established either by a recognized document or the test plan, Tables 1 through 4 (para 4.2.2.2, 4.2.3.2, and 4.2.3.4) are used as guidelines. To provide data comparable to data from previous vehicle tests, the conditions listed in these tables should be included in the testing.

4.2.1 Familiarization Run.

4.2.1.1 Method. Before accumulating data, make a familiarization run over the gravel, bump, zig-zag, and gently rolling terrain (if used) courses. Observe the stabilization system for proper and safe functioning, and note the existence of sight or system resonant vibration frequencies.

4.2.1.2 Data Required. Record the following:

a. Any evidence of system malfunctioning and courses on which it occurred
b. Sight or system resonant vibration frequencies

c. Any safety hazards

4.2.2 Nonfiring Tests.

4.2.2.1 Hull Motion. Record the vehicle hull motion produced by each test course to determine the disturbing input for which the stabilization system must correct and to provide a basis for comparing course and vehicle variables from one test to another. Obtain a record of hull motion by using a 3-axis rate gyro while conducting nonstabilized runs over each couse at each speed.

4.2.2.2 Stabilized Runs. Operate the test vehicle over the stabilization courses (para 2.1.1) toward a 2.3-meter-square target at closing speeds of 8, 16, and 24 km/hr (5, 10, and 15 mph). Speeds higher than 24 km/hr are used if vehicle capabilities permit (e.g., 16, 32, 48, or 64 km/hr (10, 20, 30, or 40 mph)), or a speed lower than 24 km/hr is substituted if excessive bouncing inhibits the crew from safely performing the run. Runs are limited to 60 seconds or 500 meters' closing range, whichever occurs first, and are made with and without gunner compensation as described below.

For the compensated (C) runs, the gunner attempts to keep his/her LOS on the target, closing the firing switch each time he/she feels that a hit can be made. Conduct each C run using at least two gunners (the same individuals for all tests) with each making three runs at a stationary target at each speed (Table 1) on each course. Repeat these test conditions with the target moving across (perpendicular to) the vehicle's path at speeds up to 64 km/hr at reduced ranges (Table 2).

For noncompensated (NC) runs, the gunner makes an initial lay on the target at the starting point, then removes his/her hands from the controller for the run, allowing the system to operate unaided. If the weapon drifts, it is not realigned during the run. If the gun drifts to the position where the target is outside the field of view of the TV camera, however, quick re-lays are sometimes permitted so that the record of the gun position is not lost. Runs are made on the gravel and bump courses, but not on the zig-zag course unless the stabilization system corrects for azimuth translational displacements of the vehicle in relation to the target. Make at least six runs toward a stationary target at each speed on each course. The same or different gunners may be used for this phase since individual skills do not affect the outcome.

4.2.2.3 Data Required. For each C or NC run, as applicable, record the following data:

a. Type test (C or NC), identity of gunner, type course

b. Weather and condition of course

c. Vehicle speed (km/hr)

d. Maintenance requirements (see TECOM Suppl 1 to DARCOM-R 700-15[8] for appropriate data required for each element - maintainability indices, tools and TMDE, etc. -of the maintenance evaluation.

e. Horizontal and vertical gun boresight target point displacement (mils) with respect to time (seconds)

f. Pitch, roll, and yaw turret and hull rates with respect to time (seconds)

g. Trigger pulses versus time (correlated to theoretical hit capability)

h. Synchro error signals between sight and gun (for systems with gun slaved to stabilized sight)

i. Safety hazards discovered during operation

Table 1. Typical nonfiring compensated test - stationary target.

Target: 2.3 meters square
Initial range: 2,000 meters
Time of each run: 60 seconds

Course	Vehicle Speed (mph)	Time on Target* (avg. %)
Gravel	5	90
	10	85
	15	80
Bump	5	80
	10	75
	15	65
Zig-Zag	5	80
	10	75
	15	75

Table 2. Typical nonfiring compensated test - moving target.

Target: 4.6 x 2.3 meters
Target speed: up to 64 km/hr
Time of each run: 60 seconds

Course	Vehicle Speed (mph)	Starting Range (meters)	Time on Target* (avg. %)
Gravel	5	1,500	95
	10	1,500	90
	15	1,500	85
Bump	5	1,500	85
	10	1,500	80
	15	1,500	70
Zig-Zag	5	1,500	85
	10	1,500	80
	15	1,500	75

*These values represent desirable goals

4.2.3 Firing Tests.

4.2.3.1 Preparation for Firing Main Gun.

a. Boresight the guns and sights at the range specified in the technical manuals, or if no manual exists, at a range appropriate for the weapon system being tested. Record range in meters.

b. Zero the sights for the main gun by firing three rounds followed by an additional three-round group for confirmation. Record target dispersion and pertinent meteorological and ballistic information.

c. With the tank stationary, fire three 5-round groups from the ready racks to determine the optimum firing rate of the main gun. Record hits and rates of fire.

d. (Optional) Mount rugged TV camera to gun sight as described for nonfiring stabilization testing. Use automotive fire control data acquisition system to record all data.

4.2.3.2 Main Gun Firing on the Move. Make runs on each of the stabilization courses at the speeds and other conditions given in Table 3. Higher speeds than those indicated are used if vehicle capabilities permit (e.g., 16, 32, 48, or 64 km/hr), or a lower speed is substituted if excessive bouncing inhibits the crew from safely performing the run. The firing procedure is as follows:

a. For large-caliber weapons, load the vehicle with five rounds in the ready rack for each gunner per test condition. For automatic main weapons (such as 25-mm guns), load feed trays with sufficient ammunition to provide three short bursts (five rounds) for each gunner per test condition. A minimum of two gunners is used.

b. At the start of each run, position the vehicle sufficiently behind the course starting point to allow for accelerating to the prescribed speed.

c. Accelerate the vehicle to the prescribed speed.

d. With the vehicle moving toward the 2.3-meter square of the target (4.6 by 2.3 meters for the moving targets), load, lay, and fire the gun as accurately and rapidly as possible. If use of the optical rangefinder is impossible for moving operations, the commander resets the rangefinder at 50-meter intervals to maintain superelevation to correspond to the approximate range. The ranging error therefore never exceeds 50 meters.

e. Limit the runs to 60 seconds or, for test speeds exceeding 24 km/hr, 1,100 meters closing range to limit the variation in range to the target when firing. If the five rounds are not fired during the initial run, make additional runs to complete each exercise.

Table 3. Typical stabilizer firing test - main gun.

Test	Starting Range, meters	Vehicle Speed, mph	Target Speed, mph	Course
Closing on Stationary Target				
1		5	0	Gravel
2		10	0	Gravel
3		15	0	Gravel
4		5	0	Bump
5	1,500	10	0	Bump
6		15	0	Bump
7		5	0	Zig-zag
8		10	0	Zig-zag
9		15	0	Zig-zag
10	1,000	5	0	GRT
11	1,000	10	0	GRT
12	1,000	15	0	GRT
Closing on Stationary Target				
13		5		Gravel
14		10		Gravel
15		15		Gravel
16		5		Bump
17	1,500	10	15	Bump
18		15		Bump
19		5		Zig-zag
20		10		Zig-zag
21		15		Zig-zag
22	1,000	5	10	GRT
23	1,000	10	10	GRT
24	1,000	15	10	GRT

Notes:

Two gunners are used, each firing 5 rounds (inert projectiles) per test.
Problem time for each test: 60 seconds

GRT = gently rolling terrain (an optional test).

4.2.3.3 Coaxial Machine Gun Firing.

a. Functionally fire the coaxial machine gun, using at least 50 rounds fired in short bursts at 25 meters, to record static dispersion. Additional groups may be fired at 100, 300, and 500 meters to assess static dispersion at stabilizer test ranges.

b. Fill the ready box with ammunition.

c. Make firing runs over each of the stabilizer courses at the speeds established previously. Starting ranges to targets are 100, 300, and 500 meters. Limit runs to 10 seconds to minimize range variation. Use at least two gunners, each to make three runs per test condition (Table 4).

d. Fire at the 6- by 6-meter stationary targets (and the moving targets) to capture as many impacts as practical for measuring dispersion and hits.

Table 4. Stabilized cupola and coaxial machine gun firing.

Test	Vehicle Speed, mph	Target Speed, mph	Course
Closing on Stationary Target			
1	5	0	Gravel
2	10	0	Gravel
3	15	0	Gravel
4	5	0	Bump
5	10	0	Bump
6	15	0	Bump
7	5	0	Zig-zag
8	10	0	Zig-zag
9	15	0	Zig-zag
Closing on Crossing Target			
10	5	15	Gravel
11	10	15	Gravel
12	15	15	Gravel
13	5	15	Bump
14	10	15	Bump
15	15	15	Bump
16	5	15	Zig-zag
17	10	15	Zig-zag
18	15	15	Zig-zag

Notes:

Problem time for each test: 10 seconds.
Starting ranges in meters: 100, 300, and 500.
Each problem is repeated using a second gunner.
Each gunner makes 3 runs at each speed.

4.2.3.4 Cupola-Mounted Gun Stabilization Systems. To accomplish tests of cupola-mounted systems, use the applicable portions of the above test procedures.

4.2.3.5 Data Required.

a. Main Gun Firing on the Move.

(1) Identity of gunner
(2) Type of course
(3) Vehicle speed (km/hr)
(4) Target speed and direction
(5) Weather and condition of course
(6) Maintenance requirements (see App. N of TECOM Suppl 1 to AR 750-1)
(7) Round temperature at firing
(8) Target impact locations (measured from point of aim)
*(9) Ranging time (interval from range initiation to final position of sight reticle)
*(10) Range at which each round is fired
*(11) Loading time (interval from trigger pulse to breech closure on next round)
*(12) Firing time (interval from trigger pulse to next trigger pulse)
*(13) Lead angle employed (by computer - signal from computer to reticle is calibrated and monitored)
*(14) Gun/sight LOS
*(15) Internal parameters (e.g., cant, wind sensor, superelevation, etc)
(16) Safety hazards uncovered during firing runs

*optional measurements

b. Machine Gun Firing.

(1) Same as in a (1) through (6) above
(2) Number of rounds fired for each test condition
(3) Target impact data (location and extreme spread, horizontal and vertical, of impacts and number of impacts within borders of each target rectangle) for each test condition
(4) Stoppages, causes of stoppages, course on which malfunction occurred
(5) Safety hazards uncovered during firing runs

5. DATA REDUCTION AND PRESENTATION.

5.1 Nonfiring Tests.

a. For high sample rates (more than 100 Hz), calculate the percent of time on target from the recorded horizontal and vertical displacement data as follows: Divide each test run into increments and analyze each increment to determine whether the positions of gun and sight are satisfied for an "on-target" condition. Calculate percent of time on target for each run by adding the number of occurrences in which the above conditions are satisfied and dividing that total by the total number of increments for each run.

For low sample rates, connect the points (see Figure 1), and derive on-target time by calculating percent of segment within target boundaries. Then, add all of the segments.

For systems employing the concept of gun slaved to a stabilized sight, additional treatment of data may be required. In these systems, the gun may not be in the same position as the sight when the gunner actuates the trigger for an on-target condition due to the response lag of the system. It is necessary, therefore, to evaluate the time-on-target data when the gun is on target, the sight is on target, and when both the gun and sight are on target.

Prepare charts of percent time on target as a function of various angular target sizes (1/4, 1/2, 3/4, 1, 1-1/2, 2, 2-1/2, 3, 4, and 5 mrads) for each test condition (App. B). Compare time-on-target values with established criteria.

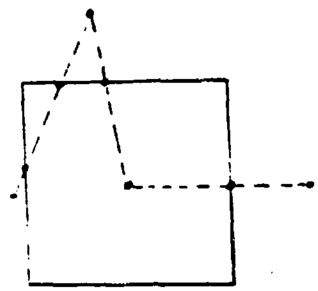

Figure 1. Time-on-target data plot.

b. Calculate simulated firing rates for each test condition. (Rates of simulated fire demonstrate the comparative ease of stabilized firing for the various test conditions. A comparatively slow rate of fire is an indication of greater aiming difficulty. These data do not necessarily represent the true rate of fire since many factors such as recoil, reloading, breech closure, and reacquisition times are not represented.)

c. Calculate percentage of hits for each test condition based on simulated firings and gun positioning relative to specific target sizes. (Simulated hit performance data provide a measure of how well the gunner can work with the stabilizer system.) Segment each test run into 0.5-second increments that follow the gunner's trigger pulls (simulating the length of time that a gunner would maintain trigger pull). Analyze each increment to determine whether or not the conditions of gun, sight, and trigger pulse are satisfied for a hit on the target. Calculate the hit percentage as the ratio of the number of satisfied condition instances (simulated target hits) to the total number of instances (trigger pulls).

For systems employing the concept of gun slaved to a stabilized sight, additional treatment of data may be required. In these systems, the firing pulse may be inhibited if the gun and sight are not within a predetermined alignment tolerance range. It is necessary, therefore, to correct the hit percentage data, taking into consideration the number of trigger pulls that would actually result in a firing pulse.

d. See TECOM Suppl 1 to DARCOM-R 700-15 for calculation of the maintainability indices (mean time to repair, maintenance ratio, achieved availability, and any other required indices). See Appendices O through R of the

same reference for charts presenting maintenance, parts, maintenance package literature, and tools and TMDE data analyses.

5.2 Firing Tests.

a. Main Gun Firing. From the projectile impact data, calculate the center of impact (CI) and standard deviation of hits about the CI (both horizontal and vertical) for each condition, each gunner, and for all gunners combined.

Compute average rate of fire for each condition, each gunner, and for all gunners combined.

Determine a point estimate and 90% confidence interval on hit probability on the 2.3- by 2.3-meter target from the above data, and present it in tabular form (hit probability for each test condition with combined gunner results). Assume that horizontal and vertical impacts are independently and normally distributed random variables, with the distribution centered at the observed CI. Also determine hit probability versus vehicle speed for each course and condition.

Compare these data with established criteria and performance of previous stabilization systems.

See Appendix N of TECOM Suppl 1 to AR 750-1 for calculation of the maintainability indices and Appendices O through R of the same reference for charts for presenting the data.

b. Machine Gun Firing. Calculate and tabulate the CI and standard deviation of impacts about point of aim and standard deviation of CI's about points of aim.

Tabulate the extreme spread (horizontal and vertical) and percentage of hits on each target size and test condition and compare with established criteria. If no criteria are available, compare with unstabilized vehicle hit performance for similar target conditions (firing stabilized on the move versus firing from unstabilized stationary vehicle). These data provide a measure of the effectiveness of the stabilization system in preventing loss of firing accuracy while on the move.

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APPENDIX A

BODE PLOTS

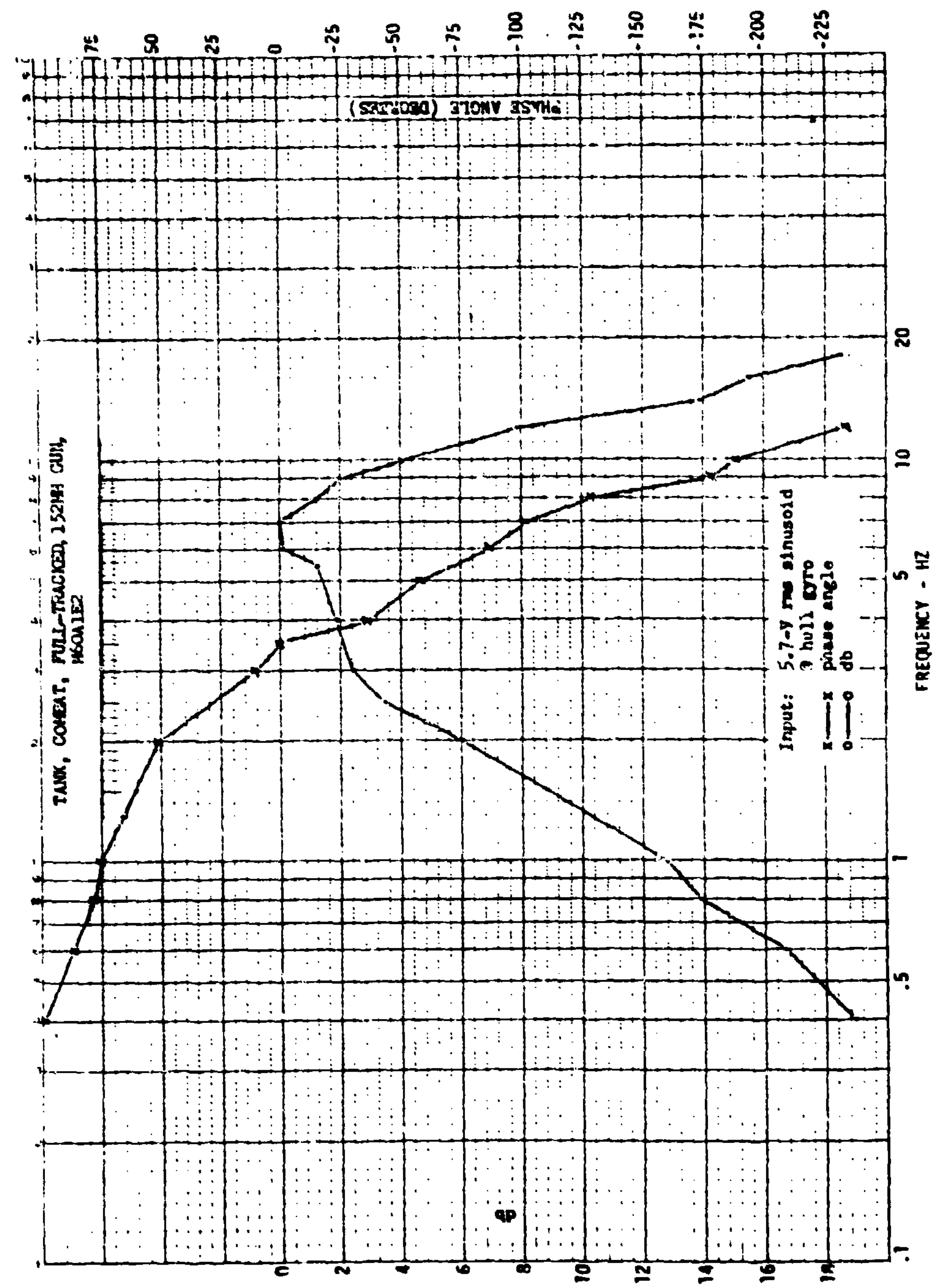

Figure A-1. Frequency response, turret (azimuth), 5.7-volt rms input.

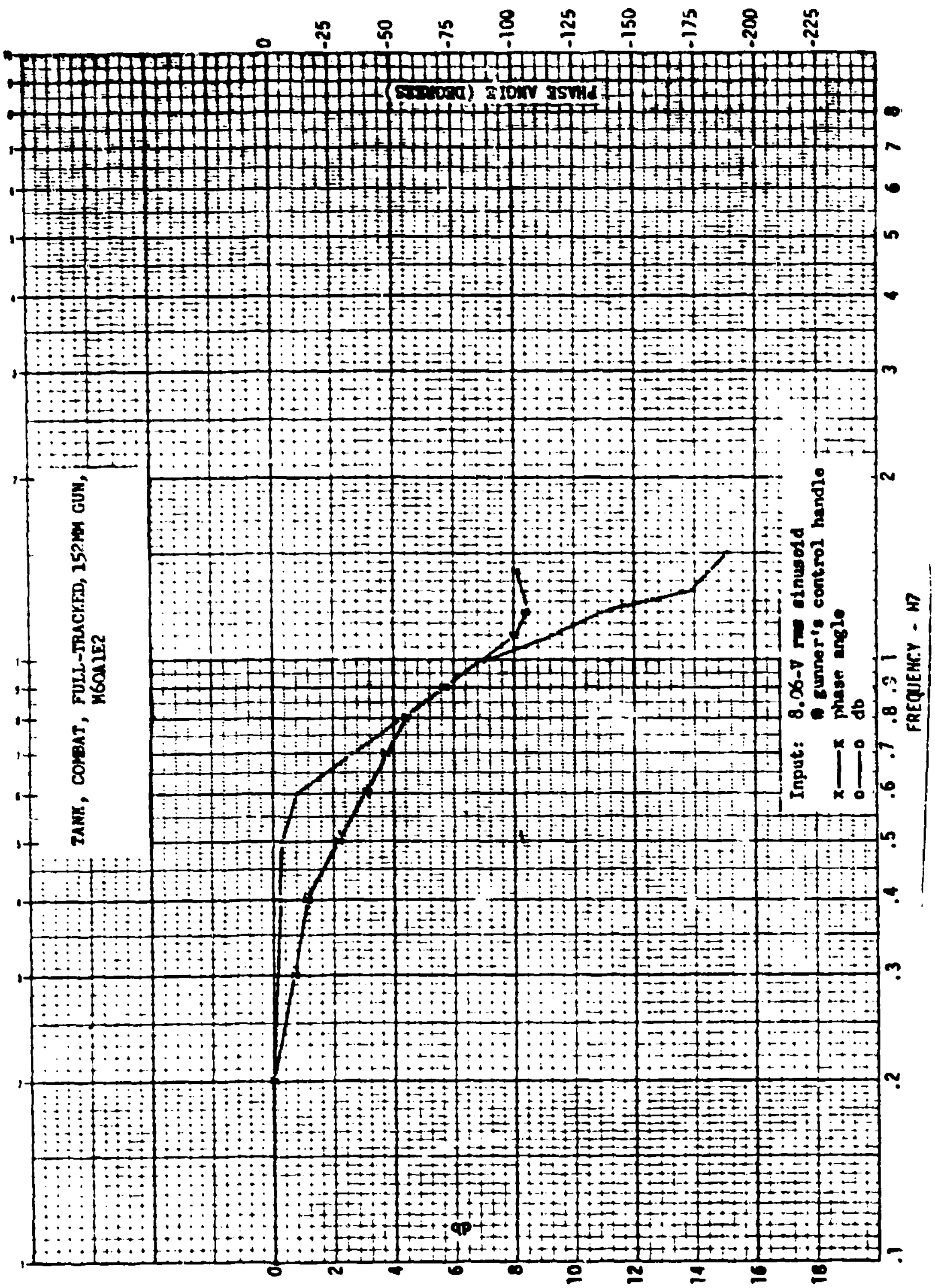

Figure A-2. Frequency response, turret (azimuth), 8.06-volt rms input.

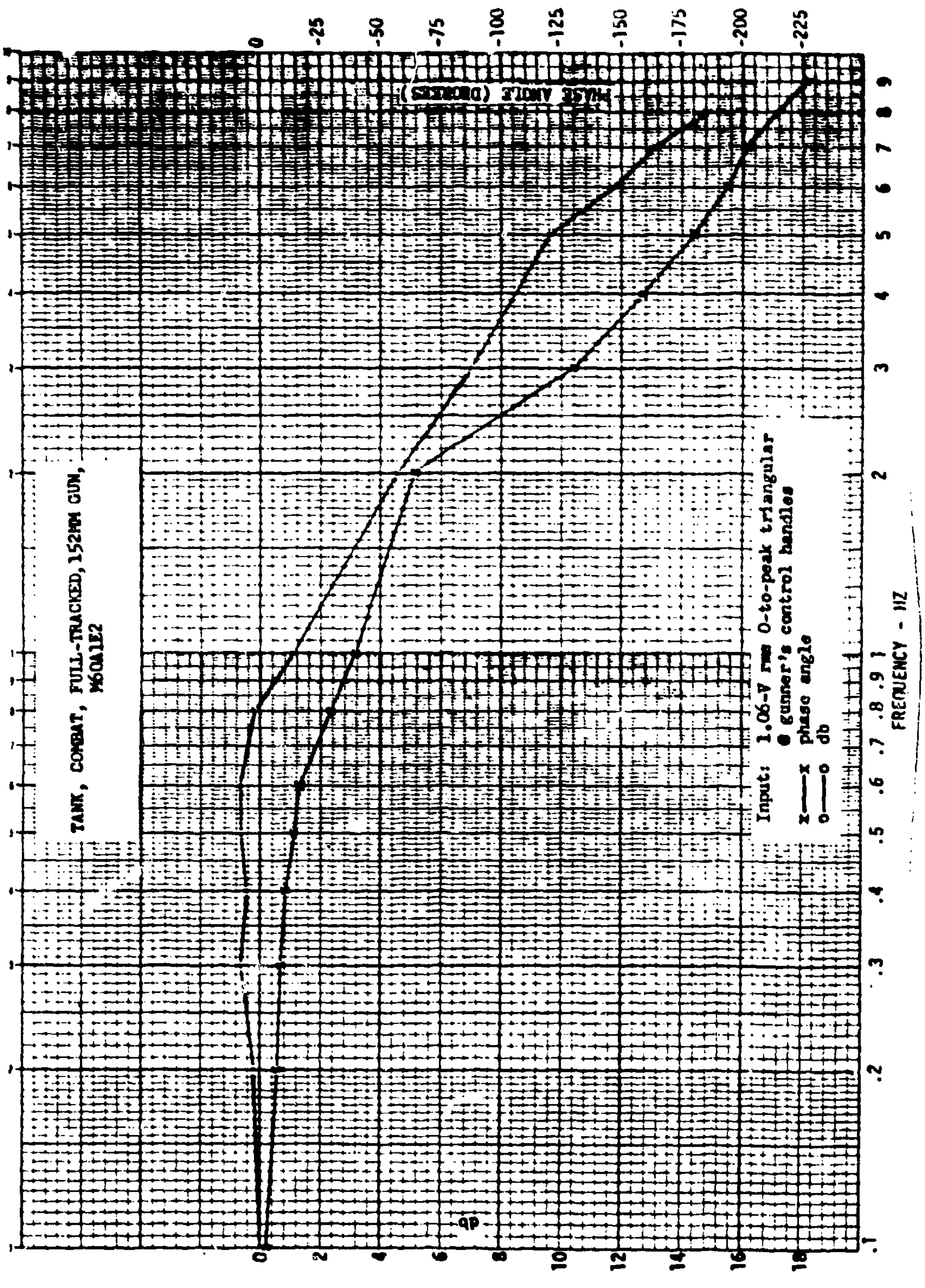

Figure A-3. Frequency response, turret (azimuth), 1.06-volt rms input.

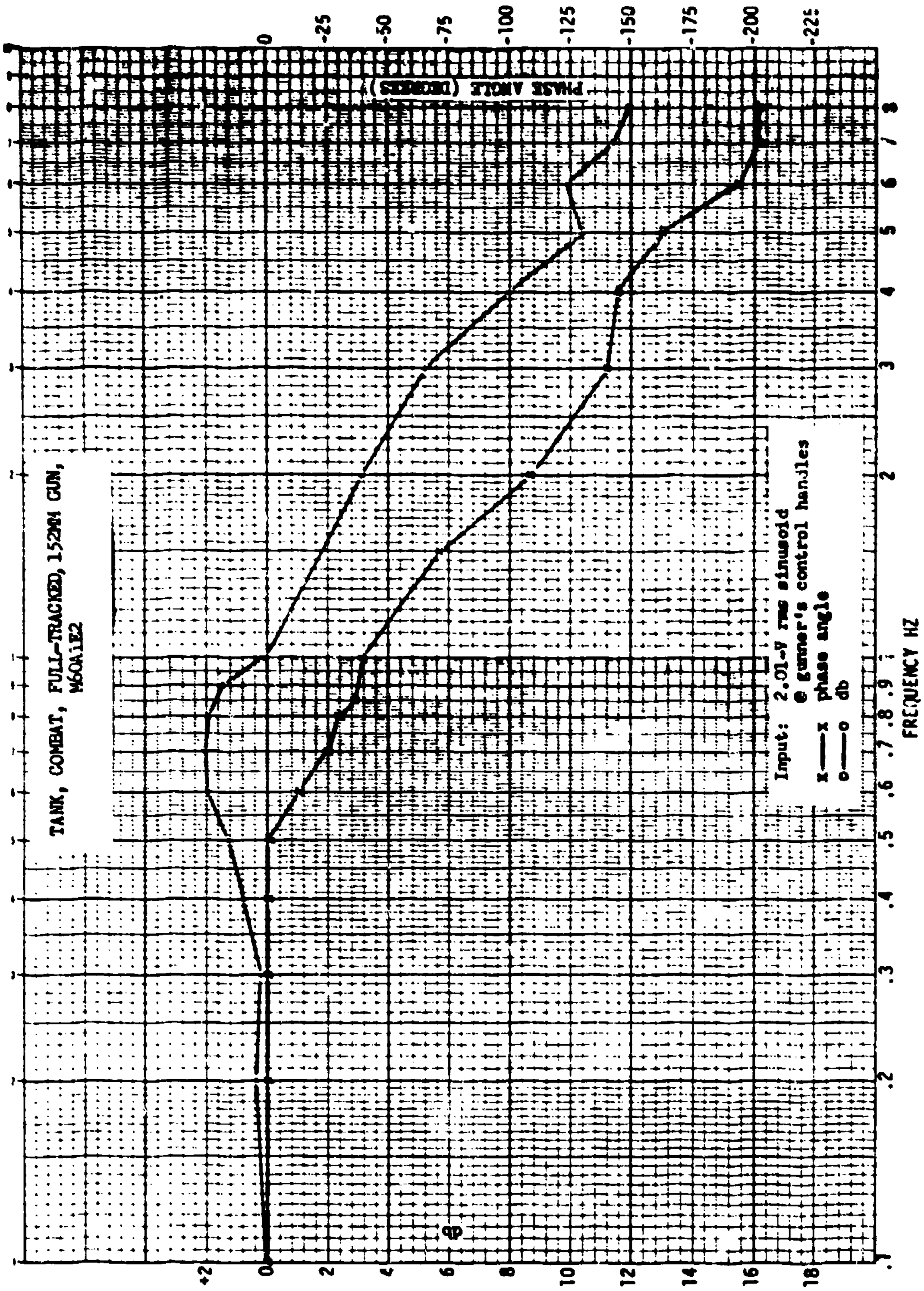

Figure A-4. Frequency response, main gun (elevation), 2.01-volt rms input.

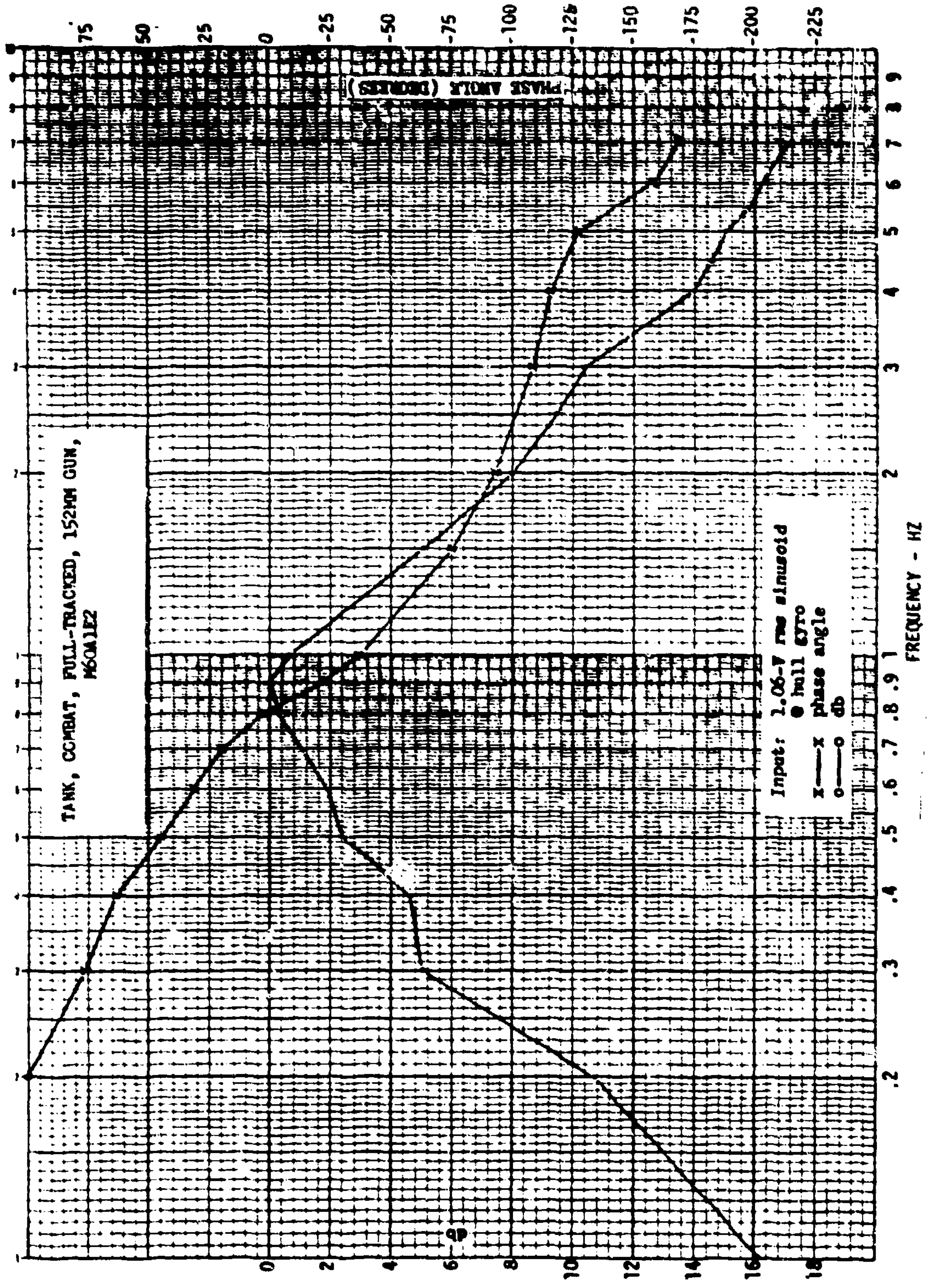

Figure A-5. Frequency response, main gun (elevation), 1.06-volt rms input.

APPENDIX B

SAMPLE CHARTS DEVELOPED FROM NONFIRING DATA

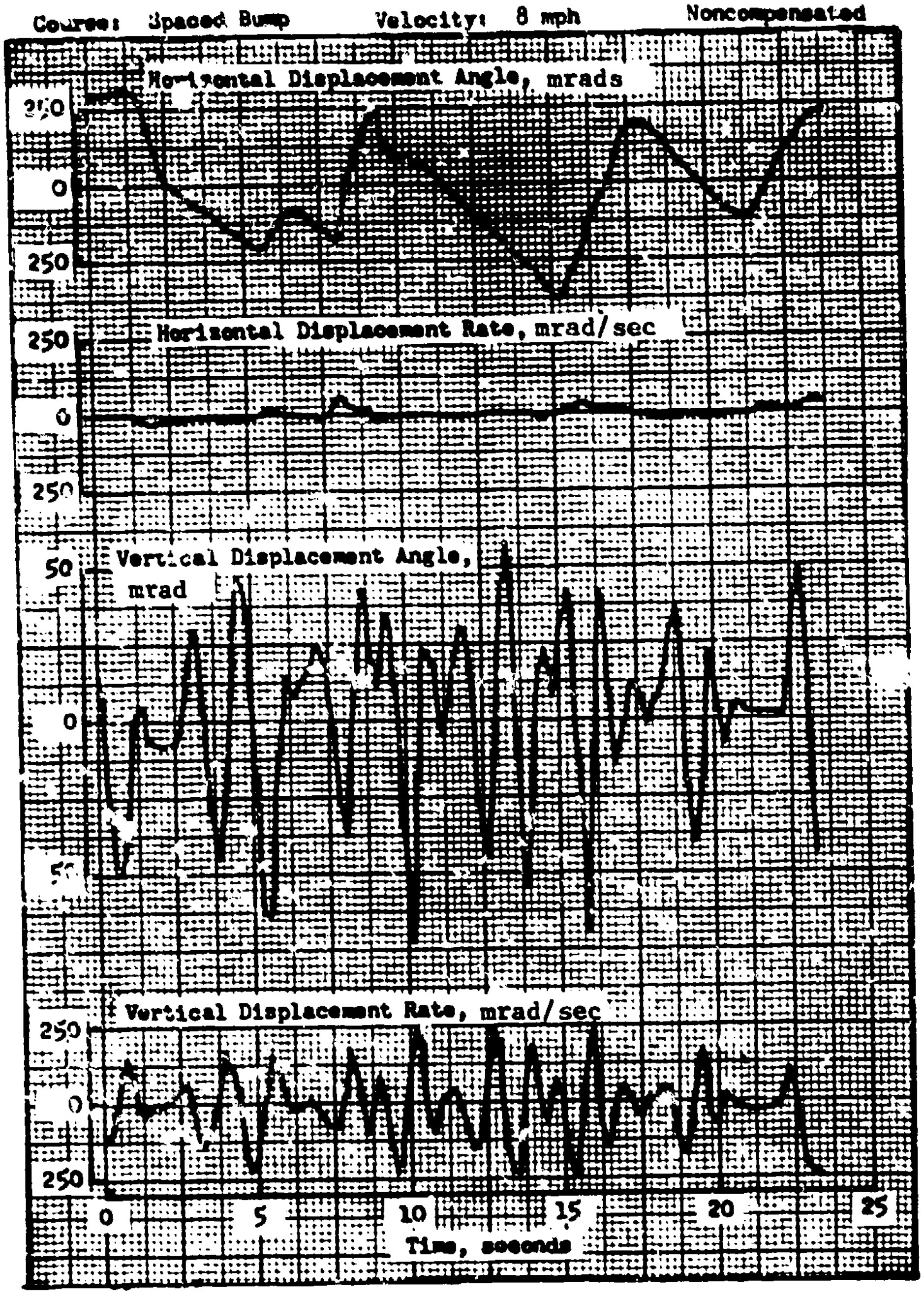

Figure B-1. Hull displacement and angular rate versus time.

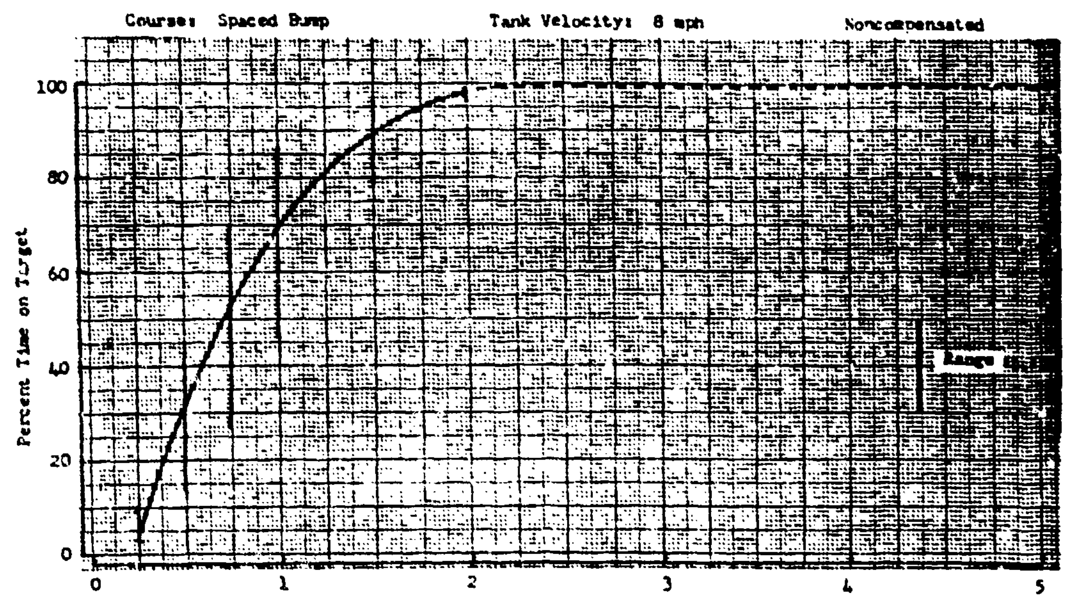

Figure B-2. Percent time on target versus target size for M60 tank with Code B stabilizer (calculated about mean).

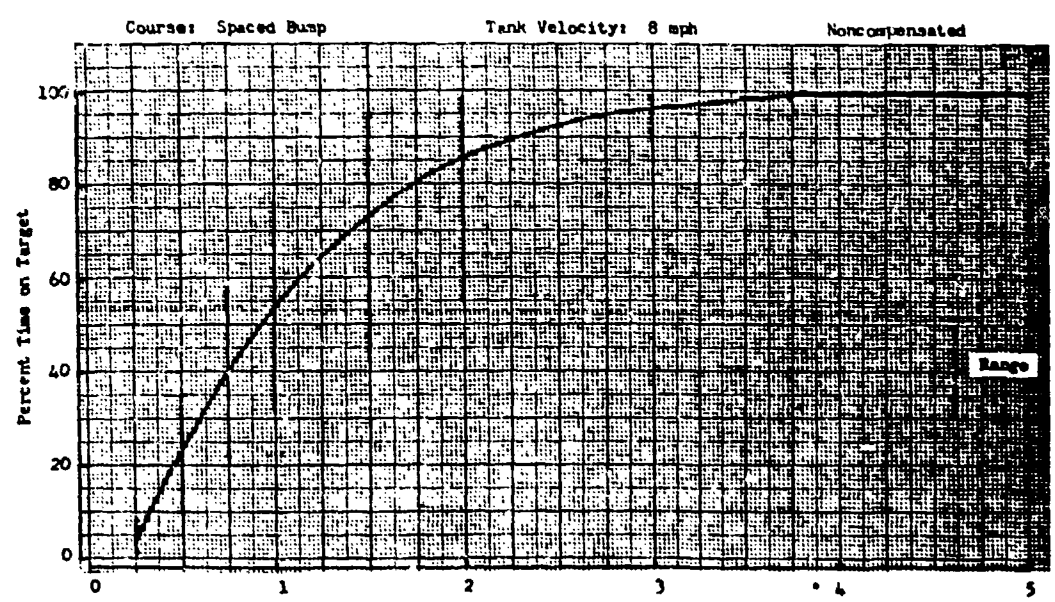

Figure B-3. Percent time on target versus target size for M60 tank with Code B stabilizer (calculated about calibration).

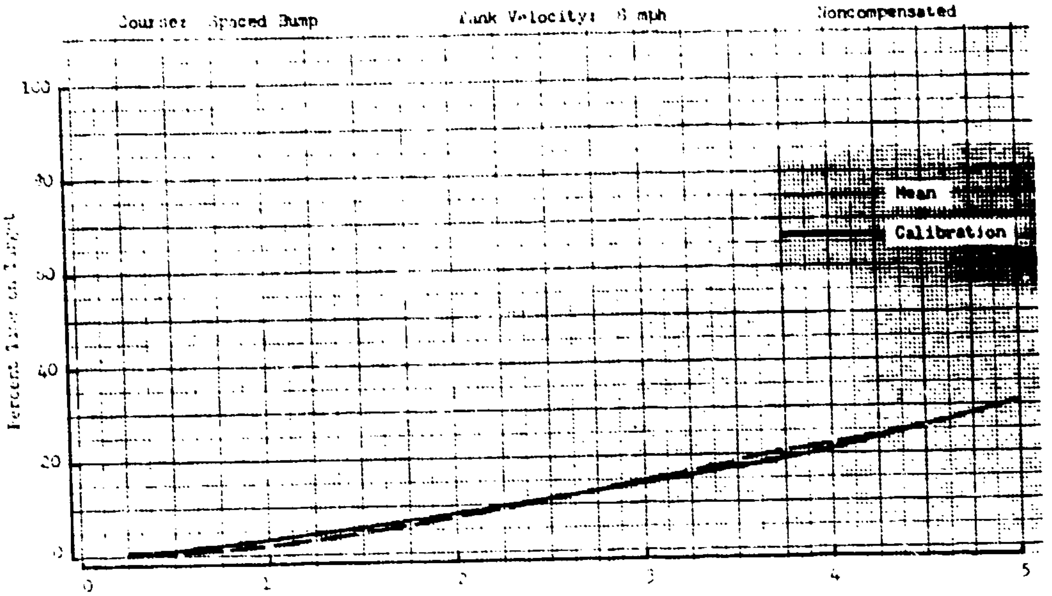

Figure B-4. Percent time on target versus target size for M60 tank with Code A stabilizer (1965).

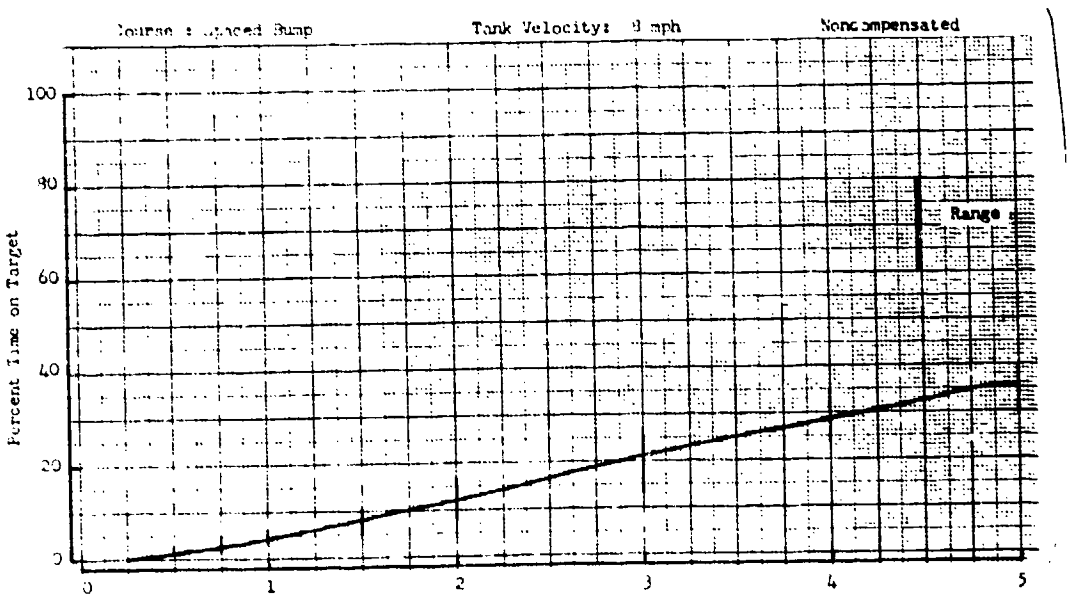

Figure B-5. Percent time on target versus target size for M60 tank with Code A stabilizer (calculated about mean).

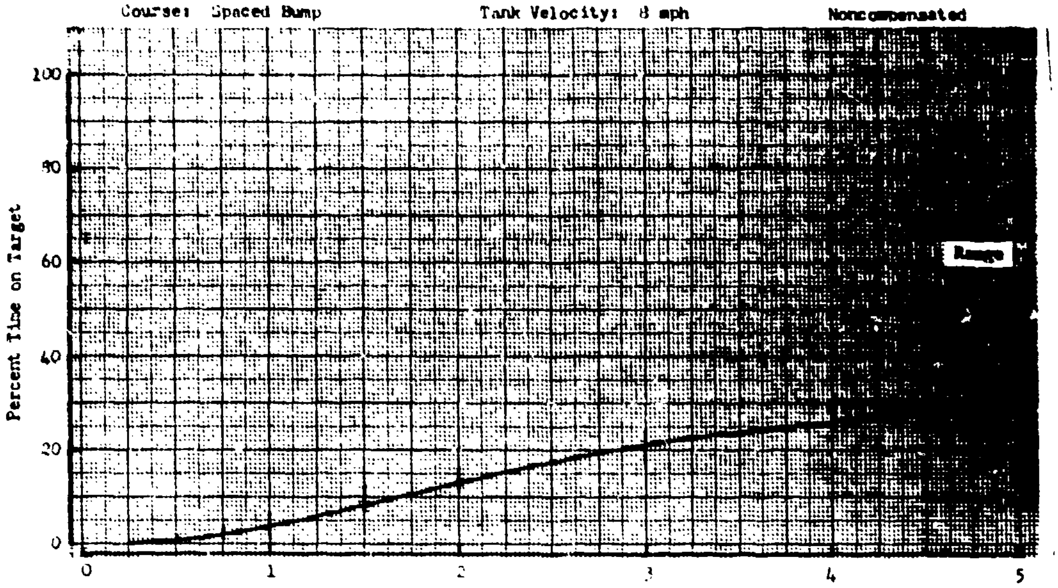

Figure B-6. Percent time on target versus target size for M60 tank with Code A stabilizer (1967) (calculated about calibration).

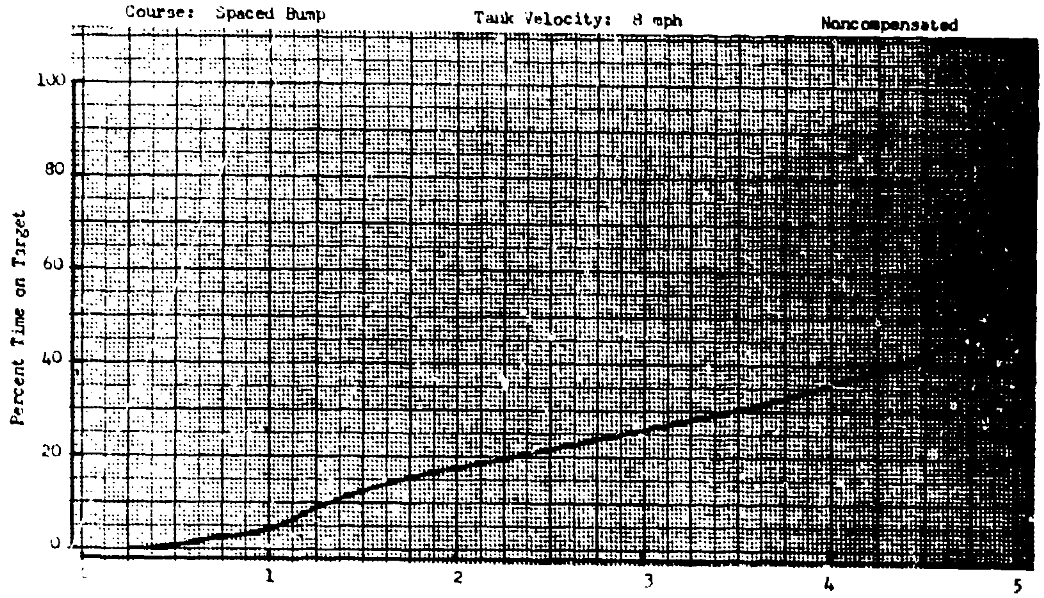

Figure B-7. Percent time on target versus target size for M60 tank with Code C stabilizer (calculated about calibration).

APPENDIX C

REFERENCES

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